The Granular Cosmic Vacuum: A Structural Truth about Dark Energy and Dark Matter

Chabane Dahli
Independent Researcher, Algeria
dahlichabane70@gmail.com

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Abstract

The Granular Cosmic Vacuum (GCV) proposes that what is usually called "empty intergalactic space" is in fact a granular, string–membrane structure. The smooth Einsteinian vacuum is replaced by a lattice of microscopic white holes (MWs), each stabilized by three contracted temporal strings. In this framework, dark energy is not a mysterious fluid nor a quantum vacuum energy, but the geometric tension of a closed temporal string extended over cosmological scales. Dark matter is not made of unknown particles either: it arises from the pressure of closed spatial membranes located in galactic halos. We present a structural model in which the effective dark–energy density is obtained from a damped Planck–scale tension, while the dark–matter phenomenology is generated by membrane pressure without any particle component. We derive an additional damping factor for high–energy gamma rays crossing the granular lattice and a tiny, distance–dependent correction to the Casimir force at 100 nm–1 μm. Both predictions are quantitatively formulated and can be tested with existing and upcoming gamma–ray telescopes and ultra–precise Casimir experiments. In this sense, the GCV provides a structural truth about dark energy and dark matter as emergent effects of the cosmic string–membrane vacuum, and it offers a falsifiable, particle–free alternative to ΛCDM.

Keywords— Granular cosmic vacuum; microscopic white holes; contracted temporal strings; dark energy; particleless dark matter; spatial membranes; gamma–ray attenuation; Casimir effect.

1 Introduction

The standard ΛCDM paradigm describes the large–scale structure of the Universe with remarkable observational success. However, it leaves the physical nature of its two main components—dark energy and dark matter—essentially unexplained. Dark energy is usually modeled as a cosmological constant Λ or a scalar field, leading to the cosmological constant problem when compared to quantum vacuum energy estimates. Dark matter is generally postulated as a new class of non–baryonic particles, but no direct detection has been achieved so far.

In this work we present an alternative view based on the idea of a *Granular Cosmic Vacuum* (GCV). Instead of a smooth vacuum filled with quantum fields, the intergalactic "desert" is a granular lattice of microscopic white holes (MWs) and strings, while the dark–matter phenomenology emerges from spatial membranes rather than from particles. Within this framework:

- Dark energy is the geometric tension of a closed temporal string, structurally damped from the Planck scale to the Hubble scale.
- Dark matter is the effective gravitational manifestation of closed spatial membranes, without any new particle species.

The GCV thus recasts the "mystery" of dark energy and dark matter into a structural property of space–time itself.

2 Three Structural Domains: P_1, P_2, and P_3

We distinguish three ontologically different domains in the Universe, each with its own physical description.

2.1 P_1 – Interior of Galaxies

The domain P_1 corresponds to the interior of galaxies:

- A four–dimensional Lorentzian manifold $(M, g_{\mu\nu})$.
- General Relativity (GR) and Quantum Field Theory (QFT) are locally valid.
- Standard Model fields, Hilbert spaces, quantum states, entanglement, and the usual QFT vacuum are present.
- All laboratory and high–energy experiments are performed in P_1.

In P_1 the GCV does not modify the well–tested predictions of GR and QFT.

2.2 P_2 – Intergalactic Desert (Temporal Region)

The domain P_2 is the intergalactic vacuum, or "desert":

- There is *no* global QFT vacuum and no global Hilbert space.
- The fundamental entities are microscopic white holes (MWs), forming a granular lattice of vacuum grains.
- Each MW is a stacked configuration of three mass membranes (mass–branes) and is stabilized by three contracted temporal strings (a $3 \to 1$ temporal rule).
- These three contracted temporal strings combine to form an effective *closed temporal string* extending over cosmological scales.
- Photons crossing P_2 are no longer QFT excitations but *string photons*: waves of temporal tension on the closed string network.

The tension of this closed temporal string is identified with the observed dark–energy density.

2.3 P_3 – Galaxy Edges and Halos (Spatial Region)

The domain P_3 corresponds to galaxy edges and halos:

- There is no particle dark matter; instead, the region is filled with closed spatial membranes.

- These membranes are formed by a ternary composition ($3 \to 1$) of contracted spatial branes.
- The internal pressure of these membranes, and their curvature, generate an effective gravitational field reproducing flat rotation curves and lensing.

Dark matter is therefore interpreted as a *structural pressure effect* of spatial membranes, rather than as a fluid of unknown particles.

3 Dark Energy as Temporal String Tension

3.1 Planck–Scale Tension and Structural Damping

We assume that the fundamental tension scale is of order the Planck tension,

$$T_{\mathrm{P}} = \frac{c^5}{G\,\ell_{\mathrm{P}}} \sim 10^{70}\,\mathrm{J/m}, \qquad \ell_{\mathrm{P}} \approx 1.6 \times 10^{-35}\,\mathrm{m}. \tag{1}$$

The closed temporal string in P_2 is built from this basic scale but its effective cosmic tension is reduced by a structural damping across many hierarchical levels from ℓ_{P} to the Hubble radius R_H.

We model this damping by an exponent $0 < \lambda_{\mathrm{struct}} < 1$:

$$T_{\mathrm{cosmic}} = T_{\mathrm{P}} \left(\frac{R_H}{\ell_{\mathrm{P}}} \right)^{-\lambda_{\mathrm{struct}}}, \qquad R_H = \frac{c}{H_0}, \tag{2}$$

where H_0 is the Hubble constant.

3.2 Effective Dark–Energy Density

The dark–energy density is the energy per comoving volume provided by the cosmic string tension:

$$\rho_\Lambda = \frac{T_{\mathrm{cosmic}}}{R_H} = \frac{T_{\mathrm{P}}}{R_H} \left(\frac{R_H}{\ell_{\mathrm{P}}} \right)^{-\lambda_{\mathrm{struct}}} \approx 10^{-9}\,\mathrm{J/m^3}, \tag{3}$$

which naturally matches the observed order of magnitude.

In Einstein's equations, this tension enters as an effective cosmological constant

$$T_{\mu\nu}^{(\text{tension})} = -\,T_{\text{cosmic}}\, g_{\mu\nu}, \qquad \Lambda_{\text{eff}} = \frac{8\pi G}{c^4}\, T_{\text{cosmic}}, \tag{4}$$

with equation of state $w \approx -1$. Thus, in the GCV picture:

> *Dark energy is the geometric tension of cosmic time—a property of the closed temporal string—and not a quantum vacuum energy nor a mysterious fluid.*

4 Dark Matter as Spatial Membrane Pressure

In domain P_3, closed spatial membranes act as sources of an effective gravitational field. Each membrane has an internal pressure p that can be expressed as

$$p \sim \frac{T_{\text{P}}}{\ell_{\text{g}}^2}, \tag{5}$$

where ℓ_{g} is the characteristic spacing between membranes (the granular scale in the halo). If many such membranes are distributed throughout the halo, the effective dark–matter density becomes

$$\rho_{\text{DM}} \approx \frac{p}{c^2}. \tag{6}$$

This structural density can reproduce:

- Flat rotation curves around galaxies.
- Gravitational lensing amplitudes usually attributed to cold dark matter.

Hence,

> *Dark matter is the macroscopic effect of spatial–membrane pressure and curvature, not a fluid of undetected particles.*

5 High–Energy Gamma–Ray Attenuation in the Granular Vacuum

5.1 Standard ΛCDM Attenuation

In standard cosmology, a high–energy gamma ray with energy $E \gtrsim$ TeV from a distant blazar or GRB interacts with CMB/EBL photons via

$$\gamma + \gamma_{\rm CMB/EBL} \to e^+ + e^-, \tag{7}$$

producing an optical depth $\tau_{\rm pair}(E, z)$. The predicted flux is

$$F_{\Lambda\rm CDM}(E, z) = \frac{F_{\rm em}(E)}{4\pi D_L^2(z)} \, \exp\big[- \, \tau_{\rm pair}(E, z)\big], \tag{8}$$

where $F_{\rm em}(E)$ is the intrinsic emitted spectrum and $D_L(z)$ is the luminosity distance.

5.2 Extra Damping from the Granular Lattice

In P_2, the photon becomes a string photon propagating through the MW lattice and the temporal string network. This leads to an extra, small damping encoded by

$$\Gamma(D, E, \gamma_N) = \exp\big[- \, \gamma_N \, f(D, E)\big], \qquad \gamma_N \ll 1, \tag{9}$$

with a phenomenological function

$$f(D, E) = \Big(\frac{D}{\ell_{\rm g}}\Big)^{\alpha} \Big(\frac{E}{E_0}\Big)^{\beta}, \qquad \alpha > 0, \; \beta \geq 0. \tag{10}$$

The observed flux becomes

$$F_{\rm obs}(E, z) = \frac{F_{\rm em}(E)}{4\pi D_L^2(z)} \, \exp\big[- \, \tau_{\rm pair}(E, z)\big] \, \Gamma\big(D_L(E, z), E, \gamma_N\big). \tag{11}$$

We define the residual ratio

$$R(E, z) = \frac{F_{\rm obs}(E, z)}{F_{\Lambda\rm CDM}(E, z)} = \exp\big[-\gamma_N \, f(D_L(E, z), E)\big] \approx \exp\left\{ - \gamma_N \Big(\frac{D_L}{\ell_{\rm g}}\Big)^{\alpha} \Big(\frac{E}{E_0}\Big)^{\beta} \right\}, \tag{12}$$

which predicts a small, systematic extra attenuation increasing with distance and, possibly, with energy.

6 Granular Correction to the Casimir Effect

6.1 Standard QED Result

For two parallel, perfectly conducting plates of area A separated by distance d, QED predicts

$$F_{\mathrm{QED}}(d) = -\frac{\pi^2 \hbar c}{240\, d^4}\, A. \tag{13}$$

6.2 Effect of Vacuum Granularity

In the GCV picture, the region between plates is not a continuous vacuum but contains a finite density of MW grains and string segments. The plates modify the local structure of this lattice and hence the allowed modes. We express the total force as

$$F_{\mathrm{total}}(d) = F_{\mathrm{QED}}(d)\Big[1 + \delta_{\mathrm{gran}}(d)\Big], \tag{14}$$

with a tiny correction

$$\delta_{\mathrm{gran}}(d) = \kappa\Big(\frac{d}{\ell_{\mathrm{g}}}\Big)^n, \qquad \kappa \ll 1,\ n > 0. \tag{15}$$

The measurable deviation is

$$\Delta F(d) = F_{\mathrm{meas}}(d) - F_{\mathrm{QED}}^{(\mathrm{corr})}(d) \approx F_{\mathrm{QED}}(d)\, \delta_{\mathrm{gran}}(d). \tag{16}$$

Thus, a systematic non–zero $\Delta F(d)$ at separations $d \sim 100\,\mathrm{nm} - 1\,\mu\mathrm{m}$ would be an experimental signature of vacuum granularity and would constrain ℓ_{g} and κ.

7 Truth about Dark Energy and Dark Matter in the GCV Model

Within the Granular Cosmic Vacuum framework, the physical content of "dark" components can be summarized as follows:

- **Dark energy** is the large–scale manifestation of the tension of cosmic time, realized as a closed temporal string built from three contracted temporal strings per MW. Its magnitude is determined by structural damping from the Planck scale to the Hubble scale.

- **Dark matter** is the gravitational effect of closed spatial membranes in galactic halos. Their internal pressure and curvature act like an effective mass distribution, without invoking any new particles.

Hence, the "truth" about both components in this model is structural and geometric, not particulate: they are emergent properties of a granular vacuum composed of microscopic white holes, contracted temporal strings and spatial membranes.

8 Predictions and Falsifiability

The GCV model is experimentally testable through:

1. **High–energy gamma–ray astronomy:** measurement of $R(E, z)$ from Fermi–LAT and ground–based Cherenkov telescopes (HESS, MAGIC, VERITAS, CTA) to detect or constrain the extra damping $\gamma_N f(D, E)$.

2. **Precision Casimir experiments:** searches for a small, systematic deviation $\Delta F(d)$ at $d \sim 100\,\mathrm{nm} - 1\,\mu\mathrm{m}$, sensitive to $\delta_{\mathrm{gran}}(d)$ and the granule scale ℓ_{g}.

A consistent set of null results at sufficient precision would strongly constrain or even rule out the granular corrections; positive detections with the correct distance and energy dependence would support the GCV picture.

9 Conclusion

We have presented a LaTeX–ready formulation of the Granular Cosmic Vacuum, in which dark energy and dark matter are realized as structural effects of a string–membrane vacuum rather than as new forms of matter or quantum vacuum energy. The model introduces three domains P_1, P_2, and P_3; explains dark energy as temporal string tension and dark matter as spatial–membrane pressure; and provides explicit, testable predictions in gamma–ray astronomy and Casimir physics. In this way, it offers a coherent and falsifiable alternative to the standard ΛCDM paradigm.

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